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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/615,057	07/08/2003	Tushar Prasad	1789-11201	8027

23505 7590 06/20/2007

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EXAMINER	
GAKH, YELENA G	

ART UNIT	PAPER NUMBER
1743	

MAIL DATE	DELIVERY MODE
06/20/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/615,057	PRASAD ET AL.	
	Examiner	Art Unit	
	Yelena G. Gakh, Ph.D.	1743	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *03 May 2007*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-6,15 and 16* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-6,15 and 16* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *04/13/07*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. RCE, filed on 05/03/07, and amendment, filed on 04/13/07, are acknowledged. Claims 1-6 and 15-16 are pending in the application.

Response to Amendment

2. Objection to the specification and rejection to the claims are sustained. Potential art rejection is established.

Specification

3. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

4. The specification is objected to as not containing "a written description of the invention ... in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains ... to make and use the same".

In particular, according to the Summary of Invention, "the present sensors exploit the superprism phenomenon, which causes a large deflection of a light beam in a photonic crystal when the incident angle of the light changes only slightly". From Detailed Description of the Preferred Embodiments it appears that creating such "superprism phenomenon" requires rigorous calculations including calculations of the band structure of the crystal, all possible values of wave vectors in 3D space, dispersion surface, input-output characteristics of any input ray, propagation direction, the largest non-linear response for the input ray (i.e. the largest variation in the output), etc. Only then it is possible to position the light source 30 and crystal 10 such that the superprism effect of the crystal can be used to increase the sensitivity of the sensor in the composition of the solution. No particular calculations are provided in the Detailed Description or Examples, although "the results of these calculations are plotted [in] Figure 4" (page 8). It does not appear from the disclosure, that the calculations that are only outlined in the disclosure can be considered trivial. Furthermore, the specification reads, "once the internal propagation direction is determined, it is possible to compute the shift in the position of the transmitted ray *if the geometry of the sample is specified.* Using this information, it is possible to determine an

optimum angle and frequency for an incoming light beam that can be used effectively to indicate changes in the photonic crystal". The specification is silent as to what is meant by the step of "specifying the geometry of the sample", which is a liquid disposed in the crystal, and how such step can be performed. Without this step it does not seem possible to compute the shift in the position of the transmitted ray, which is essential for performing the claimed method. No working examples for photonic crystal with superprism effect used as a sensor are provided in the specification.

The examiner considers the present specification inadequate to meet the enabling requirements for using photonic crystals as sensors the way it is claimed in the application.

Claim Rejections - 35 USC § 112

5. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claims 1-6 and 15-16 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the enablement requirement. The claim(s) contains subject matter, which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

The Breath of the Claims

Claim 1 recites a sensor for detecting the presence of an analyte in a solution, comprising "a photonic crystal containing the solution", "a light source emitting a light beam at an angle to said photonic crystal" and the "light beam having a wavelength", "wherein said angle and said wavelength of said light beam are capable of producing a superprism effect in said photonic crystal"; and "a position sensing detector for detecting a change in the position of the light beam after the light beam is transmitted through said photonic crystal and the solution". Since any light source is capable of emitting a light beam at any angle and a wavelength, the specific angle of the emitted light is not a physical limitation for the light source, and therefore the claim broadly recites a light source, "a photonic crystal containing solution" and a position detector.

The position detector is supposed to detect changes in the position of the light beam going through the photon crystal. However, since the photon crystal is claimed as containing the same solution, the sensor will not be able to detect any changes, since no changes occur in the system.

The Nature of the Invention

According to the specification the sensor is based on creating a superprism effect in the photonic crystal, which requires rigorous calculations and constructing corresponding photonic crystal. The disclosure is related to a purely theoretical model of such photonic crystals without any confirming experimental data. The language of the specification is suggestive, i.e. "once the internal propagation direction is determined, it is possible to compute the shift in the position of the transmitted ray *if the geometry of the sample is specified.* Using this information, it is possible to determine an optimum angle and frequency for an incoming light beam that can be used effectively to indicate changes in the photonic crystal. By way of the example, the magnitude of the beam displacement as a function of refractive index was calculated for two different incident angles and at several different wavelengths" (page 8). The specification is silent as to what is meant by the expression "specifying the geometry of the sample", which is supposed to be liquid in the crystal, or how such geometry can be determined. Without this step it does not seem possible to compute the shift in the position of the transmitted ray, which is essential for performing the claimed method.

The State of the Prior Art

The phenomenon of the "superprism effect" of photonic crystals, i.e. "high angular dispersion based on a rapid change of the group propagation angle with wavelength in a photonic crystal" (Gerken et al., Proceedings of the SPIE, 2005) is well known in the art, see e.g. Kosaka et al. "Superprism phenomena in photonic crystals: toward microscale lightwave circuits" (J. Lightwave Technology, 1999), Wu et al. "Superprism phenomena in photonic crystals (Physical Review B, 1998). Optical sensors based on changes of refractive indices in the samples containing various analytes, which determine the change of the effective index by change in the outcoupling angle measured by a photodiode array or position dependent photodetectors, are also well known, see Tiefenthaler et al. (US 4,815,843), especially col. 7, lines 31-44). "A further

measuring method makes use of the *relation between the angle of incidence W1, at which optimum incoupling occurs, and the laser wavelength.* In this measuring method the angle of incidence W1 remains constant and the wavelength of a tunable laser is changed in such a way that the intensity of the guided mode 8 maintains its maximum or, respectively, a constant value, while the effective index is changed by the influence of the sample 3. *From the change of wavelength the change of the effective index is determined*" (col. 7, lines 9-20). Having "high angular dispersion based on a rapid change of the group propagation angle with wavelength in a photonic crystal", it would have been obvious for any person of ordinary skill in the art to assume that optical sensor based on changes in refractive indices due to the presence of analytes would be most pronounced in photonic crystals possessing superprism effect. However, no experimental data are found in the prior art, which demonstrate application of such correlations of refractive indices to determining the nature and/or quantity of the analyte in superprism photonic crystals. The examiner assumes that this is related to a non-obvious solution of finding such correlations and performing real experiments for real photonic crystals possessing superprism effects.

The Level of One of Ordinary Skill and
The Amount of Direction Provided by the Inventor

The specification does not provide an adequate disclosure for any person of ordinary skill in the art to construct the sensor recited in the claims, i.e. the sensor based on a specific photonic crystal possessing superprism effect, which would be capable of determining the presence of the analyte in the solution on the basis of changing angle of the output light beam. On the other hand, any change in refractive index of the crystal material will lead to change in this angle, whether this is an analyte or any unknown impurity in the solution. The disclosure is silent as to how the sensor would be capable of detecting the specific analyte in the solution *vs.* such impurities. Moreover, the construction of the sensor is based on rigorous calculations not fully provided in the disclosure, which makes developing such sensor un-enabled to any person of ordinary skill in the art. Moreover, it appears that the crystal, even if can be somehow constructed, can work only for a specific solution, since the construction takes into account the refractive index of the solution (see page 5 of the specification).

The Existence of Working Examples

No working examples for the sensor recited in the claims are provided in the specification. The only example, provided in the specification, demonstrates calculated theoretical sensitivity of the propagation angle of light in a photonic crystal, which is well known in the art as the "superprism effect" in the photonic crystals, and is related exclusively to a theoretical model of the photonic crystal possessing superprism effect. Moreover, the Applicants indicate that only partial calculations were performed for the instant application and that "the band structure must be calculated from Γ *to all possible points* on the surface of the Brillouin zone, rather than merely the high symmetric points". The disclosure does not lead to presumption that such calculations are trivial and well known for any person of ordinary skill in the art. Otherwise, the Applicants were expected to provide full calculations along with real experimental data for the claimed sensor.

The Quantity of Experimentation Needed

to Make or Use the Invention Based on the Content of the Disclosure

From all indicated above the examiner draws a conclusion that it would have been an unnecessary burden of experimentation for any practitioner in the art to practice the invention, taking into account its inadequate disclosure, which does not appear to enable the claimed sensor at the present state of the art.

Potential Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. The factual inquiries set forth in *Graham* **v.** *John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.

2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

8. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

9. If the claimed sensor were enabled, **claims 1-6 and 15-16** would have been rejected under 35 U.S.C. 103(a) as being unpatentable over any optical sensors based on changes in effective refractive index well known art, see e.g. Tiefenthaler et al. (US 4,815,843), in view of Kosaka (J. Lightwave Technology, 1999) or Wu et al. (Physical Review B, 1998).

Optical sensors based on changes of refractive indices in the samples containing various analytes, which determine the change of the effective index by change in the outcoupling angle measured by a photodiode array or position dependent photodetectors, are well known, see Tiefenthaler et al. (US 4,815,843), especially col. 7, lines 31-44. "A further measuring method makes use of the relation between the angle of incidence W1, at which optimum incoupling occurs, and the laser wavelength. In this measuring method the angle of incidence W1 remains constant and the wavelength of a tunable laser is changed in such a way that the intensity of the guided mode 8 maintains its maximum or, respectively, a constant value, while the effective index is changed by the influence of the sample 3. From the change of wavelength the change of the effective index is determined" (col. 7, lines 9-20).

The phenomenon of the "superprism effect" of photonic crystals, i.e. "high angular dispersion based on a rapid change of the group propagation angle with wavelength in a photonic crystal" is well known in the art, see e.g. Kosaka et al. "Superprism phenomena in photonic crystals: toward microscale lightwave circuits" (J. Lightwave Technology, 1999), Wu et al. "Superprism phenomena in photonic crystals (Physical Review B, 1998).

It would have been obvious for any person of ordinary skill in the art to improve optical sensors based on changes of refractive indices for different analytes, which determine the change in the index by the change in the outcoupling angle measured by a photodiode or position dependent photodetectors, as taught by e.g. Tiefenthaler, by utilizing the superprism effect of photonic crystals, taught by Kosaka or Wu, which is expressed as a high sensitivity of the propagation angle to changes in the wavelength in the photonic crystals, because the sensitivity of the optical sensor based on changes in refractive indices due to the presence of analytes would be enhanced in photonic crystals possessing superprism effect.

Response to Arguments

10. Applicant's arguments filed 04/13/07 have been fully considered but they are not persuasive. The Applicants' arguments appear to be somehow contradictive.

Regarding objecting to the specification, the Applicants refer to MPEP 2164.01 and to the case laws, which cite "a patent need not teach, and preferably omits, what is well known in the art". In other words, calculations of the band structure of the crystal, all possible values of wave vectors in 3D space, dispersion surface, input-output characteristics of any input ray, propagation direction, the largest non-linear response for the input ray (i.e. the largest variation in the output), etc., which are necessary just to position the light source and crystal such that the superprism effect of the crystal can be used to increase the sensitivity of the sensor to the composition of the solution, are considered to be well known in the art. It appears that specifying geometry of the sample, which is a liquid in the photonic crystal, is also an obvious step for any routineer in the art, and therefore it is not described in the specification. However, on page 8 of their arguments the Applicants admit, "in view of the complexity and depth of the prior art as shown in Section II, it is also apparent that the level of skill found in persons knowledgeable in the art is very high. The Federal Circuit has expressly "held that [a] specification was enabling with respect to the claims at issue and found that 'there was considerable direction and guidance' in the specification; there was "a high level of skill in the art at the time the application was filed" and "all of the methods needed to practice the invention were well known"".

In light of all said above, it is not quite clear, as to what specifically the Applicants argue. Do they argue that the specification does not have to contain a guidance for building an inventive sensor based on the photonic crystal with a superprism effect for detecting an analyte in a solution, because constructing such sensor is within the skills of an *ordinary* person in the art, or that the specification in fact provides "considerable direction and guidance" for constructing such sensor for a person of "a high level of skill in the art"?

The examiner respectfully requests the Applicants to define more clearly, what exactly they argue regarding the examiner's objection to the specification. The examiner's position is as following: since, as the Applicants correctly indicated in their remarks, "in view of the complexity and depth of the prior art as shown in Section II, it is also apparent that the level of skill found in persons knowledgeable in the art is very high", the examiner objected to the specification as not providing "considerable direction and guidance" for "a person of a high level of skill in the art at the time the application was filed" to practice or use the invention.

Rejection of the pending claims under 35 U.S.C. 112, first paragraph. The examiner slightly modifies rejection in light of the amendment and the Applicants' remarks. In particular, in *Breath of the Claims* the examiner indicates that the specific angle and wavelength of the light beam are not structural limitations for the light source, and the position detector is not enabled to detect any changes in the system, which is static, according to the independent claim (the photonic crystal filled with the same solution, the light source, and the position detector).

Regarding the *Nature of the Invention*, MPEP 2164.02 also states: "the specification need not contain an example if the invention is otherwise disclosed in such manner that *one skilled in the art will be able to practice it without an undue amount of experimentation. In re Borkowski,* 422 F.2d 904, 908, 164 USPQ 642, 645 (CCPA 1970). Lack of a working example, however, is a factor to be considered, especially in a case involving an unpredictable and undeveloped art". The examiner explained in the previous and present Office actions, why she believes the one skilled in the art will not be able to practice the invention without an undue amount of experimentation. Also, as the applicants agreed, the field of the invention is highly complex, and the examiner considers it undeveloped. In particular, the art the examiner refers to is directed to sensors based on photonic crystals with superprism effect. If the Applicants consider this field

well developed and predictable, then it is not quite clear, as to what might be considered inventive and non-obvious in the instant application.

Regarding the *State of the Prior Art*, the Applicants argue that the lack of experimental data for photonic crystals with a number of references rendered to their theoretical calculations "reinforces the novelty and non-obviousness of the pending claims". The examiner is rather confused with this statement. On the one hand, the Applicants state that all calculations related to constructing the sensor based on photonic crystals with superprism effect and building such sensor in practice are within the skills of a routineer in the art, and therefore no working examples are required. On the other hand, in their response to the paragraph "the State of the Prior Art" the Applicants indicate that lack of experimental data for such photonic crystals in the prior art "reinforces the novelty and non-obviousness of the pending claims". The examiner believes, that the argumentation can be presented one way or another, not both ways at the same time. If the invention is novel and non-obvious over the prior art, then the full disclosure for its practice, along with working examples, is required. If on the other hand, the invention does not require a complete disclosure and working examples, then it is not apparent, as to what is novel and non-obvious over the prior art.

Regarding *Level of One of Ordinary Skill*, the examiner failed to find the disclosure related to a specific capture of an analyte by a photonic crystal, especially with the possible materials for photonic crystal listed in paragraph [0015] of the specification. The examiner does not quite understand as to which specific interactions between the photonic crystal and the analyte the Applicants refer to. In paragraph [0017] the specification discloses: "According to the present invention, this porous crystal can be used to detect minute changes in composition of a solution that fills its pores". The sensor supposedly detects changes in the refractive index of the solution in the photonic crystal. It is not apparent, as to how these changes in the refractive indices relate to the specific binding of the analyte to the photonic crystal material. The examiner respectfully requests the Applicants to refer her to the specific page and lines of the specification, where such specific binding of the analyte is disclosed. It is also unclear, as to why any changes in the solution within the photonic crystal will not result in changes of the refractive index of the solution, when the refractive index of the solution is defined by the composition of the solution, as the Applicants indicate in the disclosure, as cited above.

Publication of Jiang et al. in "Optics Express" referred to by the Applicants appears to support examiner's position. A publication in a peer-reviewed journal of experimental results for the theoretical model published three years before confirms the examiner's statement that reducing to practice theoretical models related to photonic crystals with superprism effect is not an obvious and routine practice for anyone skilled in the art.

The examiner believes that she fully responded to the Applicants arguments regarding the paragraphs "Existence of the Working Examples" and the "Quantity of the Experimentation".

The examiner established a basis for potential obviousness rejections over the prior art. While she does not believe that the disclosure enables the sensor claimed in the instant invention, the idea of a sensor, which would be more sensitive to changes in refractive index of an analyte solution than conventional optical sensors based on such principle would have been obvious for anyone skilled in the art, because conventional optical sensors measure changes in outcoupling angle depending on the changes in refractive index and wavelength – phenomenon specifically pronounced in photonic crystals with a superprism effect.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Yelena G. Gakh, Ph.D. whose telephone number is (571) 272-1257. The examiner can normally be reached on 9:30 am - 6:00 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jill A. Warden can be reached on (571) 272-1267. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

06/12/07

YELENA GAKH
PRIMARY EXAMINER